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Introduction

Once dominated by non-motorized vehicles, urban areas around the developing world have been transformed to accommodate the growing ranks of motorized vehicles, most notably motorcycles. For millions of people living in large cities of the developing world, motorcycles offer convenient and affordable personal mobility. The trend is evident in a number of Asian cities and many of them are classified as motorcycle dependent cities (MDC). Bangkok is one of the MDCs, where motorcycle population has been significant and growing (Cuong, 2009).

Many complementary factors seem to be at work to engender a high degree of motorcycle usage in Bangkok. Firstly, motorcycles allow the rider to weave through congestion, which is a common feature of traffic in Bangkok. Hence, they are appropriate for speedy transportation and express delivery service. Secondly, the road network in Bangkok is characterized by the presence of wide roads and small side streets known as 'soi' that run-off them, allowing easy access for motorcycles (Acharaya and Morichi, 2007). Thirdly, the cheap price of motorcycles enables a growing middle class population to own private vehicles. In Bangkok, the trade-in value of a second-hand motorcycle ranges from US$236 to 674 and US$842 at minimum for a new one (Xie et al, 2004). Fourthly, owing to high accessibility and low fare of the motorcycle taxis (Photo 1), they are popular among low- and medium-income people.

Photo 1: Motorcycle Taxis in Bangkok

Source: Author.

Motorcycle taxis can be found in almost every street corner in Bangkok with over 100,000 in operation today. Fares are negotiable at about US$1–1.3 per ride, compared to a US$1.2 minimum additional to per kilometre fare of taxi cars (Wechsler, 2008). Finally, the slow progress of the government in providing safe and pleasant facilities for walking as well as public transport service has in great part encouraged people to use private motorcycles and motorcycle taxis (Kodukula, 2006).

Despite the benefits, the increased use of motorcycles carries immense societal costs in forms of: (1) urban air pollution, (2) climate change impacts, and (3) accidents and safety. The popularity of two-stoke motorcycles in the past has contributed considerably to harmful levels

of urban air pollution in Bangkok, and its effect on human health is also apparent. The rise of motorcycle population has induced greater fossil fuel use and associated greenhouse gas (GHG) emissions from combustion. The emissions directly translate to the mounting concerns of global climate change. Moreover, the frequent involvement of motorcycles in accidents raises public disquiet about traffic safety. These are the major challenges arising from the use of motorcycles in Bangkok.

Figure 1: Map of Thailand

Source: United Nations Thailand, 2010

As the need for mobility and its unintended consequences continue to climb, solutions for cleaner, more energy-efficient, and safer transportation would not only improve public health and the environment, but also contribute to a more globally sustainable passenger transport sector. The purpose of this case study is to discuss the concerns regarding motorcycles in Bangkok and provide recommendations how the government could better manage these profound concerns.

Background

Thailand is situated in the heart of South-East Asia and is surrounded by the Laos People's Democratic Republic, Myanmar, Cambodia and Malaysia. It is divided into five regions: northern, northeastern, central, eastern and southern regions. The central region (where Bangkok is located) is the most extensive rice-producing area in the country and has often been referred to as the 'Rice Bowl of Asia' (UNESCAP, 2002).

Bangkok has been the capital city of Thailand since 1782 and is located on a flat plain, which is divided by the Chao Phraya River. Since 1960, Bangkok has undergone rapid urbanization and industrialization in line with the overall development of Thai economy. It has become Thailand's communication hub as well as its administrative and business centre (BMA et al, 2009). Today Bangko's metropolitan area is by far the most significant urban area in the country with almost 15 per cent of the country's total population and an average income of US$8,135 per year (2009) almost triple the national average income (UN Thailand 2010).

Due to the development pressure in the central parts of Bangkok, many people have moved to suburban areas. Bangkok has experienced a rapid expansion in the past decades, and has been subjected to an unsustainable urban development trend, called the donut effect based on population density analysis (Burapatana and Ross, 2007). The population density of inner city decreased from 15,270 persons per km^2 in 1978 to 11,090 persons per km^2 in 2000, while population density in the outer area increased from770 persons per km^2 to 1,280 persons per km^2 during the same period (Nitivattananon and Noonin, 2008). The urban sprawl of Bangkok extends to 5 neighbouring provinces, called Bangkok Metropolitan Region (BMR). Residents living in the suburban areas still need to commute daily to the business districts in

central Bangkok. Consequently, greater distance to the centre implies greater travel demand for motorized vehicles (WB, 2007).

Bangkokians can commute by various modes of public transport with potential to satisfy the growing travel demand: road-based, rail-based and water-based transport. Road transit modes consist of bus and para-transit systems, e.g. three-wheeled motorcycle taxis (tuk-tuk), motorcycle taxis (Photo 2) and passenger vans. The bus system is presently the most popular mode of road transit. There are also minibuses providing supplementary bus services around the city (Hossain and Iamtrakul, 2009). Bangkok's urban bus services are provided by a state monopoly and supplemented by private operators under subcontracts (Photo 3). The system has an insufficient number of staff operating an old bus fleet with an average age of 16 years and the fare revenues cover only about 50 per cent of its operating costs. The system has thus accumulated a deficit of over US$1.5 billion and is regarded as inefficient service provider by policy makers (WB and NESDB, 2008). Although there are 8 different government agencies responsible for transport management in Bangkok (PCD, undated), there is no clear consensus on how to reform the system.

The rail network of Bangkok consists of an inter-city rail system and an intra-city mass rapid rail system. The inter-city rail system is present in Bangkok under the authority of the State

Photo 2:Tuk-tuks provide versatile transport in Bangkok

Photo 3:Buses provide essential mass mobility in Bangkok

Source: Author

Railways of Thailand. The system serves both freight and passenger traffic (WB, 2007). The mass rapid rail system represents the most modern transit system for urban passengers of Bangkok, including the elevated and underground rail system. The operation of both systems is run by concessionaires from the private sector. The elevated system, with wider ranges of routes, serves as a more flexible option to the underground system (Hossain and Iamtrakul, 2009). However, since the service coverage of both systems remains limited, a number of passengers are forced to transfer to other modes of transportation in order to complete their journey (WB and NESDB, 2008).

Owing to the geographical advantage of Chao Phraya River running through the city, Bangkok was largely dependent on water transport in the past. The popularity of water transport has however gradually diminished. The encounters with unpleasant odours and the water splashes from the polluted canals onto the long-tailed boat passengers are amongst the leading explanations for this decreased popularity. Additionally, the insufficient accessibility

of the piers, linkages with other modes of transport and safety equipment have also led to declining patronage (Photo 4). There are currently three different types of boats in operation (express boats, ferry and long-tailed boats – Hossain and Iamtrakul, 2009).

It should be noted that the ability to use any mode of public transport in Bangkok has been crippled owing to the city's poor walkability that includes the difficulty in walking to and from the pier, bus stops and rapid rail stations. Pedestrian and sidewalks are given a low priority, as the political commitment as well as budget allocation for sidewalk management is restrained (WB and NESDB, 2008). Despite considerable potential, the wide range of public transport alternatives in Bangkok needs major upgrading and expansion in order to address the increasing demand for mobility.

Motorcycle population growth and trends

The population increase, change in land use patterns and development of new roads have led to a rapid motorization in Bangkok. In combination with the lack of government policy to curtail the motorization process, the city has reached a high level of motorcycle and car ownership before substantial mass transit systems were in place (Barter, 2004). As shown in Table 1, from 1994 to 2010, the Bangkok vehicle fleet grew at an average rate of 12 per cent per year. By 2010, there were 6.3 million registered vehicles in Bangkok out of this, 2.4 million were motorcycles.

The number of motorcycles has risen rapidly during the 1990s, leading their predominance in Bangkok's vehicle fleet (1994 –Table1). The increase in motorcycle ownership rose dramatically from 6 motorcycles per 1000 persons in 1960 to 179 in 1993 (Barter, 2000). Despite the overall increase, the growth rate of motorcycle ownership declined after the 1997, and the number of new motorcycles entering the fleet was only sufficient to replace those being retired or transferred to up-country (WB, 2007). As illustrated in Table 1, this was reflected in the minimal motorcycle ownership growth of 0.1 per cent p.a. on average (from 851,853 to 857,460 motorcycles) during 1994–2003.

During 2003–2010, the motorcycle ownership growth however regained its momentum with almost 26 per cent growth per annum – similarly to the growth rate of cars for the same period. By 2010, the number of cars had outnumbered the number of motorcycles by over 1 million vehicles and it now dominates the vehicle fleet. The increase reflects a societal preference for car ownership in Bangkok. This trend has been noticeable, especially during 1994–2003 and to a lesser degree during 2003–2010 (Table 1).

Table 1. Total number of registered vehicle in Bangkok 1994–2010

Vehicle type	1994	2003	2010	Growth	
				Annual	Total
Car	738,847	1,225,932	3,467,252	194,886	2,728,405
Motorcycle	851,853	857,460	2,446,267	113,887	1,594,414
Bus	17,457	26,225	34,787	1,238	17,330
Truck	73,145	75,800	113,854	2,908	40,709
Others	503,927	706,300	223,742	NA	NA

NB: The definition of 'others' varies between the two sources, so the growth rate is not calculated.

Source: OTP, 2010 and ADB, 2005.

Photo 4: River transport provides a traditional opportunity for transport

Photo 5: Pollution is high and traffic police wear masks

Source: Author

One of the drivers for motorization is the increased per capita income level. The pace of the private vehicle ownership growth is correlated to the Gross Domestic Product (GDP) per capita improvement. Before 1995, BMR experienced a steep rise in GDP at the rate of 8.4 per cent per year and a fall of 2 per cent per year during 1996–2000. From 2000–2005, the GDP grew at a rate of 4.5 per cent per year (Huang and Bocchi, 2009). Accordingly, the number of vehicles, especially motorcycles, grew swiftly before its marked decline after the 1997 Asian Financial Crisis (WB, 2007), and it has regained its momentum since 2003 (Table 1).

Similarly, the shift from motorcycle to car purchase can be explained by the GDP improvement. The literature on car ownership suggests a US$5,000 GDP per capita threshold (Vasconcellos, 2001),[1] as the level at which car ownership begins to take off – a common phenomenon in many metropolises of developing countries. Per capita income in Bangkok is already beyond the threshold and it continued rising from US$7,100 in 1990 to US$10,693 in 2008 (50 per cent increase – Acharaya and Morichi, 2007 and NESDB, 2009). In line with the Bangkok GDP growth, the number of cars rose sharply, at an annual rate of 26 per cent during 2003–2010, compared to 7 per cent during 1994–2003, and this has made cars the dominant mode in Bangkok's vehicle fleet (Table 1).

Despite the preferential trend for car ownership, the motorcycle has remained an important part of the vehicle fleet. Motorcycle ownership is higher among low-income household, whereas car ownership is higher among high-income households. Even with a substantial growth of GDP per capita, the low-income population remains large (Sanko et al, 2004). Motorcycle ownership has continued to grow, instead of being displaced by cars. By 2003 the rate of motorcycle ownership had reached 405 motorcycles per 1,000 persons (IDE-JETRO, 2005).

Concerning future projections, an increased motorcycle ownership is expected in Bangkok due to the expected rise in wealth and population growth. The wealth of BMR, as measured in terms of real gross provincial product, is projected to rise about 12 per cent p.a. between 2003–2025. Its population is estimated to grow at an average of 1.9 per cent p.a. to 13.5 million people living in BMR, with 8 million living in Bangkok by 2017. Without any

1. The Economist (2005) on the other hand suggested a US$6,000 threshold.

limitation of total number of vehicles, the expected increase in wealth and population are likely to induce greater suburbanization and further motorization (WB, 2007).

According to the Bangkok Metropolitan Administration (BMA) action plan (2007–2012), the government has however set a goal to minimize motorcycle and car use by prioritizing public transport, especially the mass rapid rail transit (BMA et al 2009). The government planned to improve and expand the mass rapid transit railway for the BMR with a total length of 118 kilometres and total investment of around US$4.5 billion (WB, 2007). In line with the plan, the World Bank (2007) predicts that the share of mass rapid rail transit will increase dramatically from 3 per cent to 15 per cent by 2015 (Table 2), in contrast to a fall in private vehicle use.

According to the World Bank (2007), the modal share of private cars and motorcycles in BMR is likely to decline by 6 per cent during 2005–2015, as more travel demand is

Table 2. Forecast travel demand in the Bangkok Metropolitan Region

	2005	2015
Population (million)	10.8	13.0
Travel demand (million person trips/day)	19.4	23.4
Mode of travel (%)		
Private vehicles	46	40
Mass rapid rail transit (Sky train and MRT)	3	15
Bus and other public transport	37	31
Walk	14	14

Source: WB, 2007.

transferred to the mass rapid rail transit (Table 2). Therefore, despite the potential for increase in the absolute number of motorcycles the growth rate of motorcycle ownership is expected to slow down.

Air pollution

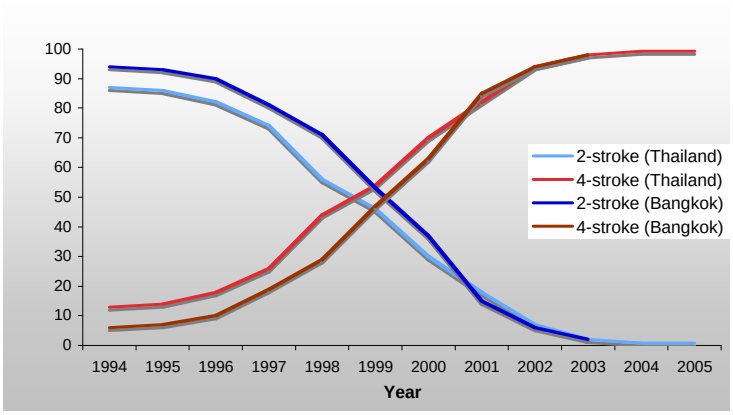
Before 2000, two-stroke motorcycles represented a dominant fraction of vehicle fleet and were the leading cause of air pollution in Bangkok. According to a study by Pollution Control Department (PCD) (Warapetcharayut and Kuson, 2001), the two-stroke engines emit high amount of unburned gasoline and twice as much hydrocarbon (HC) and suspended particulate matter (SPM) compared to the four-stroke engines. This results from their comparatively inefficient combustion of air/fuel mixture within the cylinder. They were considered to be the largest mobile source of hydrocarbon (HC) emissions at 70 per cent and also contributed 30 per cent of carbon monoxide (CO) and 14 per cent of particulate matter less than 10 microns in diameter (PM_{10}) originating from mobile sources in 1997 (Bhaopichitr and Warapetcharayut, 2001).

In 1992, the level of particulate matter (PM) in Bangkok rose beyond the National Air Quality Standards level (IGES, 2007), based on the Economic Commission for Europe standards (IGES, 2004). Furthermore, the pollution near roads had been more serious than elsewhere in Bangkok, triggering public health disquiet particularly among the traffic policemen (Photo 5) and school children – the two groups with greatest risk of exposure (IGES, 2007). To reduce

local pollutants particularly HC and PM_{10}, the government adopted a number of integrated policies and programs to actively promote the replacement of two-stroke motorcycles with four-stroke ones.

Emission standards constitute the core of the replacement strategy. From the first enactment in 1992, the standards were revised four times (1993, 1996, 1999 and 2002) to allow gradual conversion for both private motorcycles and motorcycle taxis. Tougher standards resulted in the reduction of two-stroke vehicle production. The standards were accompanied by strict enforcement (e.g. check-points, mobile inspections and motorcycle clinics, and strong collaboration with stakeholders). The PCD proposed the standard, with the Thai Industrial Standard Institute establishing the protocol, Traffic Police Division to conduct roadside checks, and the private garages to perform the annual inspection (IGES 2004). Moreover, the standard was complemented by differential excise tax, amounting to 3 per cent of the price for

Figure 2: Percentage of motorcycle sales in Thailand



Source Warapetcharayut and Kuson, 2001 and IGES, 2004

four-stroke motorcycles and 5 per cent for the two-stroke ones (Warapetcharayut and Kuson, 2001) and capacity building programs. For example, the Motorcycle Upgrade Program was launched by Bangkok Metropolitan Authority in collaboration with Thai petroleum product producers, the World Bank, and Thailand Motor Vehicle Association to help motorcycle manufacturers modify the design of their products and promote proper care of them in order to cope with more stringent emissions standards (IGES, 2004).

After the introduction of the standards, the sales of four-stroke motorcycles have grown at the cost of the sales of two-stroke motorcycles. By the fourth revision in 1999, the sales of four-stroke motorcycles already outpaced the two-stroke one. Three years after the latest revision four-stroke motorcycle sales accounted almost 100 per cent of the total sales in Thailand. A similar trend was observable in Bangkok (Figure 2). By 2000, the adoption of less-smoke producing four-stroke motorcycles led to the PM_{10} level declining (IGES 2004). In conjunction with the provision of alternative mass transit systems especially mass rapid rail transit, Bangkok succeeded in reducing PM levels by 47 per cent during 1997–2007 despite a tripling of the vehicle fleet, and this now falls within the limit set by US Environmental Protection Agency (Kallman, 2008).

Another regulation with clear success has been the fuel quality control. The phasing out of lead in gasoline, which the majority of motorcycles in Bangkok consume, was accompanied by the introduction of unleaded gasoline (completed in 1996). Following the program, the

Table 3. Level of lead concentration in Bangkok 1989-2000

Year	Annual average lead concentration ambient (µg/m3)	Annual average lead concentration roadside (µg/m3)	Policy
1989	0.43	2.16	
1990	0.44	1.42	
1991	0.3	1.55	Introducing unleaded premium gasoline
1992	0.19	0.72	
1993	0.22	0.49	Introducing unleaded regular gasoline
1994	0.11	0.27	Complete phase-out of leaded regular gasoline
1995	0.09	0.22	
1996	0.06	0.1	Complete phase-out of leaded premium gasoline
1997	0.08	0.1	
1998	0.08	0.07	
1999	0.1	0.09	
2000	0.09	0.09	

Source: IGES, 2004b.

observed level of lead in blood of school children and traffic police in Bangkok has significantly decreased (IGES, 2007). The ambient air lead concentration was reduced to near zero (UN-HABITAT, 2008). Bangkok's air quality comes within the limits set by the US, yet slightly higher than standards of the European Union (Kallman, 2008). While Bangkok's air quality is still worse than that of Asia's cleanest cities, the fall in pollution levels is increasingly apparent.

Climate change

Motorized vehicles contribute to the growing amount of CO_2 and other GHG emissions in the atmosphere, forming the principal source of GHG emissions in Bangkok (37.7 per cent). The emissions from transport sector are expected to rise further exceeding 25 million CO_2 equivalent per year (BMA et al 2009). This is because the majority of motorcycles and cars in Thailand remain reliant on fossil fuel. Although four-stroke motorcycles produce less than half of the CO_2 per passenger-kilometre of a car, fossil fuel-powered motorcycles still have considerably greater emissions than buses, rail transit and electric vehicles per passenger kilometre (Table 4).

Other emissions from motorcycles also have positive climate forcing effects, such as methane (CH_4), black carbon of particulate matter, volatile organic compounds (VOCs), nitrogen oxide (NOx) and CO (Futumata and Gordon, 2009). According to the IPCC (2007), methane is a potent GHG with global warming effect of 25 times stronger than CO_2 over a 100 year period. The black carbon is a main heat-absorbing fraction of PM and is 100 to 1,000 times more effective in warming the atmosphere than CO_2 on a mass basis. VOCs, NOx and CO emissions also have climate impacts by forming the ground-level ozone/smog (Futumata,and Gordon, 2009).

Table 4. GHG emissions from vehicles in developing countries

Vehicle type	Average occupancy	CO_2 equivalent emissions per passenger-kilometre
Car (gasoline)	2.5	130–170
Car (diesel)	2.5	85–120
Car (natural gas)	2.5	100–135
Car (electric)*	2.0	30–100
Motorcycle (two-stroke)	1.5	60–90
Motorcycle (four-stroke)	1.5	40–60
Minibus (gasoline)	12	50–70
Minibus (diesel)	12	40–60
Bus (diesel)	40	20–30
Bus (natural gas)	40	25–35
Bus (hydrogen fuel cell)**	40	15–25
Rail transit***	75% full	20–50

* Ranges are due largely to varying mixes of carbon and non-carbon energy sources (ranging from about 20-80% coal), and also the assumption that the battery electric vehicle will be smaller than conventional cars.

** Hydrogen fuel cell is made from natural gas.

*** Heavy urban rail technology powered by electricity generated from a mix of coal, natural gas, and hydropower.

Source: Sperling and Salon 2002.

With high vulnerability to flooding, climate change impacts on the city are likely to be severe. Bangkok is naturally prone to flooding and rapid urbanization in recent decades has exacerbated the effects of heavy rains; many long-existing watercourses were filled in and replaced by roads, buildings and other structures. Altogether, the vulnerability to flooding thus ranks amongst the leading concerns of climate change impacts in Bangkok. In a scenario where sea level rise by 50 cm, 55 per cent of Bangkok would be affected by floods, and 72 per cent of the city would be affected if the sea level were to rise by 100 cm (BMA et al, 2009).

To address the issues of fossil fuel consumption and climate change impacts from motorcycles in a holistic manner, the government also aims to enhance fuel-efficiency through voluntary labelling programs and proposed fuel economy standards. The labelling programs for vehicles were launched by the PCD in 2005 and by the National Energy Policy Office in 2006 to limit the level of CO_2 emissions. . Meanwhile, the government prepared a draft for fuel economy standards in 2008 (GFEI and CAI, 2010) and plans to employ the New European Driving Cycle, a testing protocol to assess the emission level of engines, in order to standardize the present vehicle testing protocol and to enhance the reliability of fuel economy data (Punte, 2010). Despite this, the Thai government still subsidizes the retail price of fuel by using the Energy Conservation Fund, which is originally intended to help pay for mass transit projects (GFEI and CAI, 2010).

Figure 3: Road accidents in Bangkok 2003-2008

Source: BMA, 2010

Accidents and safety

The statistics of road accidents during 2003–2008 reveal that cars and motorcycles are the primary types of vehicle contributing to traffic accidents in Bangkok. Motorcycles are involved in almost half of all road accidents (Figure 3). Over 80 per cent of people who were involved in motorcycle accidents in Bangkok were male, aged between 21–35 years old (Kasantikul, 2001). Although traffic congestion is a common phenomenon in Bangkok, excessive speeding remains the highest cause of road accidents, followed by unsafe passing and tailgating (BMA, 2010). Hospital data indicates that over half of the injured drivers and riders had been drinking alcohol (GRSP, undated).

Despite higher frequency of accidents when compared to other provinces, severity is much less. Of the accident cases reported in 2008, 598 fatalities were in Bangkok (Figure 3) compared to 11,561 deaths of the national figure (5 per cent .v. 95 per cent) (DLT, 2009). Primarily, this is due to the fact that traffic in Bangkok is normally congested, and this results in lower speeds. About 78 per cent of all motorcyclists in Bangkok wear helmets when riding, which reduces the potential severity from accidents by 7 times as compared with those who did not wear helmet. Another key factor is the better emergency services and treatment in Bangkok compared to other provinces, contributing to the lower fatality rates (Tanaboriboon, 2004).

In line with the total road accidents in Bangkok, the trend of motorcycle road accidents has been decreasing in recent years from 26,278 accidents in 2006 to 21,200 accidents in 2008 (Figure 3), while the number of registered motorcycles rose from 2,229,285 to 2,339,308 during the same period (OTP, 2010). One of the key drivers could be the coordinated effort to enhance road safety in Thailand. According to the Thailand Road Safety Action Plan 2004–2008, the government adopted a multi-sectoral approach and implemented strategies involving different stakeholders (law enforcement, traffic engineering, education, emergency rescue and monitoring and evaluation). Each of them contains a number of programs in order to reach to goal of reducing road deaths from 10 per cent to 5 per cent per year over 5 years. As a result, the national fatality rate has decreased by 11 per cent from 2003 to 2005 (GRSP,

Photo 6: Traffic organizes itself at the traffic lights for the next green phase

Source: Author

undated). Similarly, while Bangkok's fatality rate has decreased by 28 per cent from 2003 to 2008, motorcycle accidents have decreased by 7 per cent during the same period (Figure 3).

Conclusion

Since the early stage of Bangkok's development, motorcycle ownership has risen dramatically and it has dominated the city's vehicle fleet. But as incomes grew, the preference for car ownership has become apparent. Despite the projected increase in motorcycle ownership, the growth rate will decrease, and be further undermined by mass rapid rail transit. Motorcycles have been in large part responsible for much of Bangkok's traffic congestion (Photo 6), as well as contributing substantially to air pollution, climate change, accidents and safety. The actions taken to address these issues can offer lessons for other cities with similar problems.

Lessons learned

1. Long-term land-use planning and sufficient public transport provision during the initial stage of development is central to addressing traffic problems. Until 1999, the only public transport in Bangkok was buses, which were known to have low quality services and efficiency. Alternative public transport suitable for Bangkok (e.g. water transport) was ignored. Consequently, before sufficient public transport could be provided, Bangkok had already experienced high rates of motorcycle ownership exceeding many other Asian cities, and it became renowned for its traffic problems. By that time, prevention was no longer a viable option for Bangkok, and the city had to deal with traffic problems when they occurred.

2. Vehicle emission standards have been successful in tackling air pollution from motorcycles. Strict enforcement and a clear legal basis are both needed for improvements. Key elements to effective implementation are stakeholder collaboration, economic instruments (e.g. pricing and demand management) and capacity building. Similar comments can be made about the enhancement of road safety in Thailand, and this has also been successful. Tackling climate change problem through reducing levels of fuel use has not shown positive outcomes, primarily because of the lack of the necessary legal support and the contradictory actions from the government (e.g. on fuel subsidy).

Recommendations

Bangkok remains a motorcycle dependent city. This dependency needs to be reduced, if the efforts to address the continued growth in numbers, and the regulations and policy actions taken are not to be undermined. The continued growth will reduce the effectiveness of all the measures taken, and levels of pollution, climate change and accidents would all be exacerbated. Targeted proactive policies need to be introduced to reduce motorcycle dependency. These policies should include limits to the total numbers of motorcycles licensed, together with the improvement of mass public transport.

Limiting the total number of motorcycles

The increase in the numbers of motorcycles could be controlled by implementing a registration limit that defines the maximum allowable number of vehicles to be registered. For example, 37 cities in China have stopped allowing new vehicle registration, while 21 additional cities have limited the number of new registration (Fatumata and Gordon, 2009). Such limits could be tied to a revenue-generating mechanism, such as a quota system. In Singapore a vehicle owner must first acquire a certificate of entitlement (COE) prior to registration. The COE is issued each month to keep the growth of vehicles at optimal rate for the country (3 per cent per year) and lasts for 10 years. The vehicle owners must bid for the COE, and this generates revenues for the government (Say, 2001).

The key for successful application is strong political support. The government needs to commit to the limitation scheme by supporting research activities (e.g. feasibility studies), and through gaining support from all stakeholders. The government also needs to establish a new entity or mandate for an existing entity to determine and regularly update an optimal level for the limits, based on Bangkok's local conditions (i.e. road capacity).

The government could consider the implementation of use restrictions, where certain road sections in the central business district have been banned to motorcycles (e.g. in Guangzhou, Jakarta and Lahore) (Yardly, 2007). Restrictions could be tied to a revenue-generating mechanism by charging fees for using certain road sections. Road pricing in London and Singapore has proved a successful means to reduce demand on congested roads in the city centres (Knorr and Eisenkopf, 2007).

In Bangkok, the government should examine their experience of banning heavy trucks from parts of the city over the past 30 years (WB, 2007). Lessons should be learned particularly in terms of gaining public acceptance. The government could assign responsibility to a new entity or existing entity with a mandate to manage the implementation, identifying and updating restricted zones, as well as setting the economically optimal fee level on a regular basis.

Improvement of public transport

Providing an attractive public transport system should be the main focus of government policy, and the following options could be considered. For rail-based transport, the mass rapid rail system could be expanded and better linked with the bus system, as well as other public transport modes running along the rail track. This would improve the attractiveness of the system by minimizing forced passenger transfers – this is integrated transport. The bus system needs to be reformed. A clear governance structure with a lead agency for strategic direction, monitoring and coordinating with relevant agencies is needed in order to improve quality and efficiency of public bus services. The attractiveness of buses could be raised through

upgrading of the service with investment in a new bus fleet equipped with IT systems, such as automated fare collection system, real-time information on the bus movements, locations and expected arrival times. This would all help bus users to plan their journey better and cut down waiting time.

Water-based transport could be exploited as a competitive alternative to private transport, and at the same time provide a supplement for public land transport system. To enhance attractiveness of the water-based transport, the government should take the lead in addressing the issues of integration, investment in new facilities and safety. The government could further improve its linkages to other public transport system, especially to the expanded mass rapid rail transit. High accessibility and good conditions at the pier, as well as the availability of safety equipment must be ensured. The government must assign clear responsibilities to the boat service operators, which would be strictly monitored by a designated authority. Such a transport authority would work in close cooperation with related authorities to urgently rectify the polluted water problem (e.g. Department of Drainage and Sewage of the Bangkok Metropolitan Area and the Bureau of Water Quality Management of the PCD). Finally, the ability to walk to public transport services is crucial yet it remains poor in Bangkok. Substantial improvements in the quality of pedestrian access to public transport are a clear and low cost priority.

Bangkok is a vibrant and lively city that is growing rapidly both as an economic centre and as a major population centre in the region, but the quality of the transport has deteriorated over time. Difficult decisions need to be made over the motorization process, as this is moving from the motorcycle to the car, and as other forms of transport are being squeezed out of the limited space available. Investment is needed in the rail and bus systems, and there is also considerable potential for water transport for both people and goods. Most important of all is the need for the implementation of clear priorities for the movement of people and goods around the city, and this requires strong governance structures, strategies that can be implemented, and low cost solutions to mobility.

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